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Miller, L. A.; Scollan, Nigel D.; MacRae, John C.; Humphreys, Mervyn O.; Baker, D. H.; Theodorou, Michael K.; Moorby, Jon M.

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EFFICIENCY OF NITROGEN USE IN DAIRY COWS GRAZING RYEGRASS WITH DIFFERENT WATER SOLUBLE CARBOHYDRATE CONCENTRATIONS

L.A. Miller,[1,3] D.H. Baker, [1] M.K. Theodorou,[1] J.C. MacRae,[2] M.O. Humphreys,[1] N.D. Scollan[1] and J.M. Moorby[1]

[1]Institute of Grassland and Environmental Research, Aberystwyth, SY23 3EB, UK

[2]Rowett Research Institute, Bucksburn, Aberdeen, AB21 9SB, UK

[3]Welsh Institute of Rural Studies, University of Wales, Aberystwyth, SY23 3AL, UK

Abstract

This experiment is one of a series designed to investigate the efficiency of nitrogen (N) use in Holstein-Friesian dairy cows grazing perennial ryegrass (*Lolium perenne*) which has been bred to express high water soluble carbohydrate (WSC) concentrations. Animals grazed either a High Sugar (HS) grass or a Control (C) variety chosen on the basis of heading date compatibility. Dry matter (DM) intakes were estimated using herbage mass. Milk yields, milk constituent concentrations and plasma concentrations of β-hydroxybutyrate, glucose, total protein, albumin and urea were also measured. Forage DM intakes were similar for the two grasses. However, because of differences in the nitrogen content of the varieties (128 vs 176 g crude protein (CP) kg^{-1} DM; s.e.d. 10.5; $P<0.01$) the animals consuming the C diet received ca. 35% more dietary N. Despite this, milk yields and outputs of milk fat, lactose and total protein were similar between treatments. These data indicate that the partition of dietary N for milk protein biosynthesis was much higher ($P<0.01$) in animals consuming the HS grass, which is reflected by the lower plasma urea concentrations in these animals. It is proposed that by providing grass varieties with a better match of readily available energy and protein, significant improvements in N use efficiency can be achieved.

Keywords: Grass, dairy cows, nitrogen use efficiency

Introduction

Ryegrass is essential to ruminant production in Britain. However, the efficiency of utilisation of grass N tends to be poor for milk production, which is attributable to the high ratio of soluble N to readily fermentable carbohydrates in the rumen, since the ruminal N efficiency can be increased by the addition of sugars (Rooke et al., 1987). A series of experiments were designed to test the effect of supplying extra sugars using grass varieties bred to express high WSC concentrations. Zero-grazing studies from this series showed significant improvements in the efficiency of N utilisation by dairy cows for milk production (Miller et al., 1999a,b; 2000a), and reductions in N excretion. *In vitro* experiments have shown that this is probably due to improved rumen N utilisation, and reduced uptakes of ammonia-N by the animals (Miller et al., 2000b). The experiment reported here was conducted to assess the potential of high WSC grass when grazed outdoors.

Material and Methods

Covariate measurements of milk yield and composition were taken from 8 Holstein-Friesian dairy cows in early-mid lactation (89 days ± s.e. 5.4) grazing a standard pasture sward. Animals were then used in a continuous design 3-week grazing experiment and assigned in equal numbers to one of two treatments at random: High Sugar (HS; cv. AberDove) containing high WSC concentrations, and Control (C; cv. AberElan). Low levels of fertiliser (100 kg N ha^{-1}) were applied to the plots of both varieties in early spring, and an additional 50 kg N ha^{-1} was applied to the C variety 3 weeks prior to grazing to exaggerate between treatment WSC differences. Animals were strip-grazed on monoculture plots of the two grass varieties using electric fencing to allow a herbage availability of 54 g DM kg^{-1} live weight, with fresh material being made available twice daily immediately after milking (0800h and 1600h). Access to the previous day's grazing was permitted using a tail fence to minimise trampling and spoilage of the fresh material. All animals also received a standard dairy concentrate (890 g DM kg^{-1}; 240 g CP kg^{-1} DM; 13.5 MJ metabolisable energy kg^{-1} DM) at a flat rate of 4 kg d^{-1} fed in two equal portions at each milking. Animals were adapted to the forage treatments for 2 weeks prior to the week during which the measurements were taken. Intake was estimated using herbage mass and surface sward height difference. Plasma metabolites were measured in tail blood samples taken immediately after morning milking on three consecutive days. Whole tract diet DM digestibility was measured *in vivo* using a simultaneous zero-grazing experiment. Results were analysed using analysis of variance with adjustment for covariate, using a treatment structure of Grass Variety.

Results and Discussion

Results are presented in order of HS and C respectively. The concentrations of WSC in variety HS was consistently higher than in variety C (236 vs 166 g WSC kg^{-1} DM; s.e.d. 13.3; $P<0.001$). However, CP concentrations were significantly lower than in C (128 vs 176 g CP kg^{-1} DM; s.e.d. 10.5; $P<0.01$). Mean concentrations of neutral detergent fibre (NDF) were similar between grass varieties (463 vs 458 g NDF kg^{-1} DM; s.e.d. 7.18).

In previous, zero-grazing experiments (Miller et al., 1999a,b) cows consumed more HS than C forage and this led to improvements in milk production. In the current study, milk yield and composition were similar on both varieties (Table 1). These production data are consistent with the estimated DM intakes of the cows (17.6 vs 17.0 kg DM d^{-1}; s.e.d. 1.19), but not with the substantially reduced intakes of dietary CP on the HS treatment (2.91 vs 3.66 kg d^{-1}; s.e.d. 0.238; $P<0.05$). The link between the higher sugar content of the forage and the improved efficiency of utilisation of dietary N for milk production (26.0 on HS vs 21.5% on

C; s.e.d. 1.04; $P<0.01$) is consistent with the improvement in whole-body N partitioning found in the zero grazing study (Miller et al 1999b; 2000a). We suggest that this is due to improvements in rumen N utilisation, as was demonstrated using *in vitro* rumen simulation techniques (Miller et al., 2000b) and that this hypothesis is consistent with the lower plasma urea concentrations observed in the grazing HS animals (2.47 vs 4.35 mM; sed 0.434; $P<0.01$). Other plasma metabolites (β-hydroxybutyrate, glucose, total protein and albumin) were unaffected by treatment. Whole body N utilisation may also be improved by increased uptake of glucogenic volatile fatty acids, thus helping to spare amino acids that may otherwise be used for gluconeogenesis. Rumen VFA concentrations were not determined in the present study, but Miller et al. (2000b) reported significantly higher concentration ratios of glucogenic to lipogenic volatile fatty acids from the HS grass in *in vitro* rumen simulation experiments. In conclusion, increasing WSC concentrations in grass can lead to improvements in the efficiency of utilisation of dietary protein through improvements in rumen microbial efficiency even where the overall production of the animals is unaffected

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Table 1. Mean effect of grass variety on milk yields and milk constituent concentrations, adjusted for covariate.

	Grass variety			
	HS	C	s.e.d.	P
Milk yields, kg d^{-1}	25.1	26.7	1.39	0.304
Milk constituent concentrations, g kg^{-1}				
Fat	36.8	37.8	4.20	0.817
Crude protein	30.6	30.3	1.15	0.773
True protein	28.6	27.8	1.08	0.453
Casein	22.4	21.6	1.09	0.467
Whey	6.18	6.20	0.451	0.974
Non-protein N	0.31	0.40	0.032	0.050
Lactose	46.8	46.5	1.06	0.776